DSN Multiple-Mission Command System

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This article describes the Deep Space Network (DSN) Multiple-Mission Command System and reflects the functions of the Deep Space Instrumentation Facility, Ground Communications Facility, and SFOF elements that support it.

I. Introduction

The purpose of the DSN Multiple-Mission Command System (MMCS) is to generate and transmit commands to one or two spacecraft simultaneously from a central location. All commands are originated at the Space Flight Operations Facility (SFOF) and can be sent to one or more Deep Space Stations (DSS) for storage or transmission to the spacecraft. The system also contains self checks to assure that improper commands are not processed and a verification system to confirm that proper data have been received by the DSS.

The MMCS is made up of three basic components: the SFOF, the Ground Communications Facility (GCF) and the Deep Space Instrumentation Facility (DSIF).

II. SFOF Operations

In the SFOF all command system data are processed by the 360/75 Central Processing System (CPS). Data which are sent to the DSS are formatted into data blocks and transmitted over high-speed data lines (HSDL) to the DSS. Data from the DSS or internal to SFOF are reformatted for display in the SFOF. A permanent record of command system activity is also generated by the CPS.

Command system data can originate from two areas of the SFOF. The Command System Operations Analysis Group Area (CAG) can generate command system control data or recall system data for display. Control messages, which include Standards and Limits and Configuration Messages, are stored at the DSS and are used to control the operation of the MMCS. DSN or project supplied standards and limits are used to permit automatic monitoring of certain functions of the MMCS by the DSIF. Violation of these values results in an Alarm Message being returned to the SFOF. Standards include maximum time of execution, frequency shift limits, symbol rates, exciter frequency, spacecraft number, etc. The command instruction configuration table automatically configures the DSS equipment for a particular mission. Another type of control message is a Command Recall Request

Message, which is used to check the status of system data such as standards and limits, configuration, or commands stored at the DSS. The station responds to this message with a Recall Response Message, which is displayed at the SFOF.

The Mission Support Area (MSA) can generate Command Messages, Enable or Disable Messages, or recall system data for display. During a mission, this area is manned by project personnel. At the present time all commands are input at the SFOF MSA; however, future models of the MMCS will have the capability of receiving inputs from remote MSAs. This will enable commands to be originated at locations remote to the SFOF, sent over HSDLs, and processed at the SFOF for transmission to the DSS.

Command data that must be entered each time a command is sent include type of command (priority, timed, or free), enable status (immediate, automatic, or manual), time of transmission (if timed), and the command. Other data included in the Command Message, such as DSS number, spacecraft number, day of year, message number, etc., are automatically entered in the HSD message by the CPS.

When the Command Message reaches the DSS, a Verify Message is returned to the SFOF where it is checked bit-by-bit against the transmitted message. The Verify Message is identical to the original message except that the source and destination codes are reversed. The Verify Message also contains an alarm word (synchronous alarm) to indicate whether the received HSD command block contained an error. If no Verify Message is received at the SFOF, the Command Message will automatically be retransmitted every five seconds up to seven more times or until it is verified. If the DSS does not accept the message after eight transmissions, this information will be displayed at the SFOF.

Once the command is accepted and is in the command stack, it cannot be removed for transmission to the spacecraft until it is enabled from the SFOF. This can be done in one of three ways. An "immediate enable" command has the enable included in the command message block, and is immediately enabled upon acceptance by the DSS. When an "automatic enable" command is sent and a Verify Message is returned, the CPS automatically sends the enable in an Enable Message for that command. When a "manual enable" command is sent, the operator in the MSA must manually send an Enable Message after the verification has been received. Once a command has been enabled, it will automatically be removed from the command stack at the proper time for transmission to the spacecraft.

Any command can be deleted from the stack by sending a Disable Message from the MSA. When a command has been deleted, it cannot be processed further. A timed command can be deleted from the stack by sending a duplicate Command Message (one with the same message number and subnumber) from the MSA. Since the new command will replace the original command in the stack, this can be used to change the time of a command without first sending a Disable Message.

Certain predefined commands may be categorized as critical commands. These commands cannot be transmitted to the DSS until an interlock key is entered at the MSA.

Data may be entered into the system in one of two formats: alpha-numeric or pseudo-octal. A translate table in the CPS converts alpha-numeric or pseudo-octal inputs to binary form which is used in the HSD blocks. Data may be input from an IBM 2260 with keyboard or stored command data tables. The data tables are a set of commands constructed in the CPS from a card file or project software (COMGEN for *Mariner* Mars 1971) and activated by a 2260. Once the file has been enabled, the CPS extracts commands, constructs HSD blocks and sends them to the DSS. When the number of commands in the stack reaches a predetermined level, an Alarm Message to the CPS will inhibit any more blocks from being sent until there is enough room in the stack for one more block. This process will continue automatically until inhibited manually from the 2260 or the file is empty.

Each area also has output devices to monitor system performance. These include IBM 1443 line printers, IBM 2260, digital TV, and TTY typewriters. Input and output devices are assigned to appropriate areas by the Operations Chief (OC). Voice communications networks are also available in CAG, MSA, and Operations Control Area.

III. Ground Communications Facility

The GCF provides the communications networks for the MMCS. These include HSDLs between SFOF and the DSIF for transmission of high-speed data blocks and the voice communications between the SFOF and the DSIF.

IV. DSIF Operations

The DSIF is made up of ten Deep Space Stations around the world. The main function of the MMCS at the DSS is to automatically receive command data from the SFOF, convert these data to a form which can be recognized by the spacecraft and transmit the data to the spacecraft. The DSS also sends Verification Messages to the SFOF when HSD are received, sends Alarm Messages, and Confirm or Abort Messages. In addition to synchronous alarms, the DSS also generates non-synchronous alarms which are the result of a violation of certain predefined conditions and are sent to the SFOF in a separate Alarm Message. As a backup to the HSDL, the DSS has the capability to manually enter command data by means of typewriter based on verbal information from the SFOF over the Operational Voice Communications Subsystem. However, this procedure is only used as a last resort in the event of an SFOF or GCF failure, and only when the command transmission to the spacecraft is critical.

The DSS MMCS hardware consists of the Telemetry and Command Data Handling Subsystem (TCD) which is made up of the Telemetry and Command Processor (TCP) and the Command Modulator Assembly (CMA). The TCP accepts and stores control data, accepts and stores command data up to 24 hours or until enabled or disabled, sends Verification, Alarm and Confirmation Messages to the SFOF, configures the CMA, sends Command Messages to the CMA, and generates permanent records of command system activity.

The command stack, which is a section of the TCP, is divided into three sections containing priority (P-type), timed (T-type), or free (F-type) commands. When enabled, P-type commands are transmitted immediately and in order of their reception at the TCP. Enabled T-type commands are transmitted within one-tenth second (starting with *Pioneer F*) of their specified time of execution. If another command is in the process of transmission when a T-command transmission time is reached, the T-command is automatically aborted and deleted from the stack. Any other command which is aborted is stored in the TCP until it is re-enabled or disabled by the SFOF. When a series of timed commands are sent, the time of execution cannot be less than the time required to transmit the previous command. Enabled F-type commands are transmitted on a non-interference basis with the other commands.

There are 126 positions set aside in the TCP for the command stack. Each position can store 24 bits, or one HSD word. For *Mariner* Mars 1971, this means that the stack will hold a maximum of 42 P-commands (3 TCP positions are required for each P-command), or 24 T-commands plus 2 P-commands (5 TCP positions are required for each T-command). The TCP generates a "stack warning" alarm when more than 84 command stack positions are filled and a "stack full" alarm when all 126 command stack positions are filled.

The SFOF will normally send HSD Command Messages to the stations from a command file; however, this process is interrupted when the "stack warning" alarm is received at the SFOF. After this, the commands can only be input from the 2260 in the MSA. When a "stack warning" dealarm is generated (84 stack positions or less are filled), the SFOF will resume the automatic file procedure. When the SFOF receives the "stack full" alarm from a station, no more commands can be accepted into the stack.

If a command is executed without encountering an abort condition, the station sends a Confirm Message to the SFOF indicating the identity of the command, the time of transmission, and the actual transmitted bits. If an abort condition interrupts a command transmission, the station sends an Abort Message to the SFOF indicating the identity of the command, the time of transmission, the bit at which the abort ocurred, the actual bits that were transmitted, and the reason for the abort.

V. Command Data Records

The SFOF to station HSD command traffic is stored by the SFOF in the system data record (SDR). From this record, the SFOF generates the master data record (MDR) which is delivered to the project. The station stores the station to SFOF HSD command traffic in the original data record (ODR) for playback to the SFOF to fill in missing command data records at the SFOF. The station also makes an analog recording of the actual bit stream of each command at the output of the CMA.